Funding Outlay Analysis

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There were two objectives addressed in this study. The first objective was to attempt to identify whether funding outlay trends exist in monthly disbursements for eleven General Ledger Accounts. The second objective, which flows from the first objective, was to attempt to identify the source of montly fluctuations in disbursements. The accomplishment of those objectives will permit FMB to better track and control the General Ledger Accounts involved. The two forecasting methods which were the best were: "time series" and "monthly percentage of the annual outlay".

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EXECUTIVE SUMMARY

This study analyzed monthly expenditures for eleven General Ledger Accounts, and their composite total, that were identified by AFLC/FMB as being "contract delivery" related. The purpose of the analysis was to develop a method for forecasting monthly expenditures so that the funding for those General Ledger Accounts could be better tracked and controlled. Of the eleven General Ledger Accounts examined, a Pareto analysis showed that GLA 500 accounted for approximately 99% of the total outlays involved. Therefore, this study concentrated on only that one General Ledger Account. Moving averages, time series analysis, exponential smoothing, data offsets to simulate leadtimes, and monthly percentage of annual outlays were some of the techniques tested in developing the forecasting methodology. Correlation matrices were run to determine any significant relationships. Regression equations were calculated for those cases found to be significant.

The database used for this study covered the time period October 1984 to April 1991. The monthly outlays during that time averaged approximately $124 million with a standard deviation of approximately $41 million. Because of the high degree of scatter in the GLA 500 data, Obligations data and Accrued Expenditures Unpaid data were also analyzed. Neither of these additional data sources proved beneficial.

The two forecasting methods which were the best were: "time series" and "monthly percentage of the annual outlay". Because of the recent decreases in the AFLC Budget, the time series forecasting equation has a negative slope of $1.515 million per month. This could give misleading values if forecasts were attempted very far into the future. For example, a monthly forecast for five years from now would indicate expenditures approximately $90 million less than current levels, not necessarily a valid assumption. The forecast based on a monthly percentage of annual outlays would be more stable and although it has a marginally larger average residual error between the forecast value and the actual value, it would probably be a better method for use by FMB.

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Foreword

HQ AFLC/FMB needs to project outlays/disbursements on a monthly basis. Their current forecasting method uses annual deliveries for each fiscal year as a baseline and multiplies that baseline by historical monthly percentages to project monthly System Support Division (SSD) deliveries across a six year forecast horizon. Due to a variety of reasons, such as "progress payments" and contract deliveries being earlier or later than scheduled, that method has failed to provide the accuracy that FMB requires. FMB therefore requested XPS to assist them in developing a better forecasting method.

During the past two years, XRII (formerly MMIS) has conducted two studies involving System Support Division deliveries. The overall findings were that 17% of contract deliveries occur in the month for which they are scheduled; 27% are early and 56% are late. Those studies also concluded that annual forecasts had an average error of 5.3% but that monthly forecast errors averaged 29.5%.

Methods identified in this study will be used to forecast monthly disbursements for eleven General Ledger Accounts (which include Accrued Expenditures Unpaid and Progress Payments) to insure that projected outlay/disbursement levels are not exceeded.

Objectives

There were two objectives addressed in this study. The first objective was to attempt to identify whether funding outlay trends exist in monthly disbursements for eleven General Ledger Accounts. The second objective, which flows from the first objective, was to attempt to identify the source of monthly fluctuations in disbursements. The accomplishment of those objectives will permit FMB to better track and control the General Ledger Accounts involved.

Methodology

During the past two years, XRII conducted several studies involving System Support System deliveries. Copies of the reports documenting those studies were reviewed, as was the data that was used in those studies. Those studies found that only 17% of contract deliveries occur in the month for which they are scheduled. They also found that 27% of the deliveries are earlier and 56% are later than the scheduled delivery date. In addition, contract progress payments are creating obligations, sometimes years, before the delivery of the first item of product. The XRII studies also concluded that the method used for annual forecasting was satisfactory but that monthly forecasting methods produced an average error of 29.5%, which was unsatisfactory.

The scope of this study was limited to the analysis of the following eleven General Ledger Accounts which were identified by FMB:

GLA	Description
430	Discounts Earned on Purchases
440	Recoveries For Retail Stock Losses
445	Material Return Credits Received
465	Trade-In Allowances on Purchases
500	Purchases At Cost
540	Transportation Expenses
550	Repair Expense
59005	Contract Termination Expense

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59010   Renegotiation Costs/Price Increases

59011   Service Contract Cost

59013   Modification Costs

The actual monthly expenditures for each GLA were obtained from the Division Consolidated Trial Balance report for the time period October 1984-April 1991. The data was analyzed for trends and deviation around the mean value of monthly disbursement. A Pareto analysis of the disbursements for the eleven GLAs indicated that one GLA, GLA 500 (Purchases At Cost), accounted for approximately 99% of the composite total disbursements. A comparison of the composite disbursements and the GLA 500 disbursements is shown in Figure 1. Therefore, this study restricted itself to analysis of that single GLA. The monthly disbursements for GLA 500 are shown in Figure 2. A histogram of that data is shown in Figure 3. The GLA 500 disbursements had an average monthly value of $124.3 million with a standard deviation of $41.3 million. The other ten GLAs had average monthly disbursements ranging from a high of $854 thousand to a low of $340.

The analysis performed on the GLA 500 data centered on four separate areas:

a) analysis of GLA 500 data by itself.

b) comparison of obligation data and GLA 500 data.

c) the effect of Accrued Expenditures Unpaid.

d) use of monthly percentages.

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Analysis

Analysis Of GLA 500 Data By Itself:

The historical disbursement data for GLA 500 was used as a predictor of future monthly outlays. Lag periods of one to twelve months were used to simulate "seasonal" effects. A correlation matrix was calculated to determine the degree of relationship between GLA 500 outlays and the various lag values. The highest "r" value obtained was 0.47, which does not indicate a good statistical relationship based on a value of 1.0 signifying a perfect relationship between two variables. When the forecasts generated using these lags were compared with the actual values, the average residual difference between actual and forecast was in the $30 million to $40 million range, depending on which lag period was used (see Figure 4).

In an attempt to flatten out the peaks and valleys in the data, various "averaging" techniques were examined. Moving averages of two to twelve months were calculated, as were single exponential smoothed values using smoothing factors of 0.1, 0.2, 0.4, and 0.6. The best correlation coefficient obtained using these techniques was 0.58. Although this value is better than the one obtained using the lag method, it is still a poor fit for forecasting purposes. The average residual values between the actual outlays and the forecasts using this method were in the mid to upper $20 million range (see Figures 5 and 6).

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An analysis was made combining the "lag" and the "averaging" techniques. Moving averages and exponentially smoothed forecasts were calculated for lag periods of 1-12 months. The best correlation coefficient obtained was 0.58, the same as for the "averaging" technique by itself. Combining the two methods did not improve the forecasting relationship.

The final study of the GLA 500 data by itself was a time series analysis. The monthly outlays were regressed against "time" and a prediction equation (Forecast = 161.158 - 1.515 x time) was calculated. In the regression equation, the dollar values are millions and time is "months since December 1986". The time period December 1986-April 1991 was used to calculate the coefficients for the equation. Data prior to December 1986 was excluded from the regression equation since several large swings occurred in the data during that earlier period and a slight downward trend began in the data around that time. The correlation coefficient for the time series analysis was -0.64, giving an "r squared" for the regression equation of 0.41 (approximately 41% of the variance in disbursements is accounted for by the regression equation). This was the best correlation coefficient obtained so far. The monthly residual differences between the actual outlays and those calculated by the regression equation averaged $22 million, also the best obtained so far. Figure 7 shows the regression line plotted with the actual data for December 1986-April 1991. Figure 8 shows how the regression line would have compared to the actual data for the entire period

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October 1984–April 1991. Because of the negative slope, $1.515 million per month, care must be exercised in using the regression equation for forecasting very far into the future. For example, a monthly forecast for five years from now would be $90 million less than today's value.

Comparison of Obligation Data And GLA 500 Data:

In an effort to further explain the wide swings in the monthly outlays, other sources of data were researched for comparison with the "outlays" data that had already been analyzed. Data was obtained showing the "obligations" for October 1982–April 1991 (see Figure 9). An evaluation was made to see whether "obligations" made at one point in time showed up as "outlays" some leadtime later. Lags of 0–50 months were used to simulate leadtime. Each of the "lagged" obligations were compared with the outlays and a correlation matrix was calculated. The best correlation coefficient obtained was 0.46. The average residual differences between actual and forecast monthly values using this method ranged from $37 million to $70 million. As can be seen from Figure 9, the obligations data has severe peaks and valleys. To dampen the data, exponential smoothing (using factors of 0.2, 0.4, and 0.6) was used along with a 0–24 month lag for simulated leadtime. The correlation coefficients improved to 0.62 in two of the cases (0.2 smoothing of obligations with a 3 month lag and a 6 month lag). However this is not quite as good as the correlation coefficient of 0.64 obtained with the time series analysis discussed above. Figures 10–12 show the average monthly residual differences associated with this analysis.

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The Effect Of Accrued Expenditures Unpaid:

A portion of the GLA 500 type disbursements is broken out into a separate account OAC 45. Data was obtained for OAC 45 (Accrued Expenditures Unpaid) for the period December 1984-June 1991. That data is shown on Figure 13 along with the other GLA 500 data. As can be seen, the Accrued Expenditures Unpaid fluctuates both positive and negative. This is a revolving account that shows net monthly changes and depending on how much backlog exists, the net change for any given month between what was paid and what needs to be paid can be either plus or minus. To provide a better database the two "accounts" were combined as shown on Figure 14. It was hoped that the overall turbulence of the data would smooth out, but this was not the case as can be seen by comparing Figures 13 and 14. Calculating a correlation matrix of the combined data in Figure 14 versus obligations data with simulated leadtimes of 0-50 months resulted in correlation coefficients less than 0.35.

Use Of Monthly Percentages:

The final analysis performed, examined whether outlays changed depending on which month of the year was involved. The current forecasting method being used by FMB is based on calculating the percent of annual outlays which historically have occurred during each month of the year. After the annual funding levels have been established via the budgeting system, those factors (percents) are

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used to forecast how the outlays will occur on a monthly basis. The current factors, based on an average of FY88-FY90, are listed below:

Month	Percent
October	0.099
November	0.067
December	0.100
January	0.086
February	0.071
March	0.096
April	0.090
May	0.073
June	0.094
July	0.067
August	0.094
September	0.062

An Analysis of Variance test was run on the monthly data for FY85-FY90. The test indicated that no statistical evidence existed to support the hypothesis that outlay percentage is affected by the month in which the outlay occurred. Therefore, if "percent of annual disbursements" is to be used as a basis for forecasting monthly outlays, a factor of 0.083 (one-twelfth) should be used. Using historical percentages (the current method) for October 1984-November 1986 with the GLA 500 data for December 1986-April 1991 resulted in an average residual difference of $40.8 million between actual and forecast monthly outlays. Using the 0.083 factor with the GLA 500 data for December 1986-April 1991 resulted in an average residual

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for December 1986-April 1991 resulted in an average residual difference of $22.6 million between the actual and forecast monthly outlays. This compares favorably with the $21.9 million average residual value resulting from use of the regression equation discussed above. Because of the potential problems associated with the negative slope of the regression equation, as discussed previously, the use of a 0.083 monthly factor of the annual budget will probably result in the best forecasting method for GLA 500 monthly disbursements.

Results

With regard to the Objectives established at the outset of this study:

a) No real trend, which would assist in forecasting, was found to exist in monthly disbursements. However, recent historical data did exhibit a decrease in outlays which conforms to the overall decrease in the Defense Budget. This was discussed earlier.

b) The main source of monthly fluctuations in disbursements for the eleven General Ledger Accounts results from GLA 500, Purchases At Cost, which makes up approximately 99% of the composite disbursements for the eleven GLAs. Obligations data and Accrued Expenditures Unpaid data were also examined to ascertain the cause of scatter in the GLA 500 data. Neither of those sources provided an answer. Progress payments and erratic deliveries (as identified in several XRII studies) were the only explanations found for the volatility of the data. Another possible source of monthly fluctuations could be the operating procedures at the Finance Center in Denver. The Finance Center operations were not addressed in detail in this study since they involve more than "disbursements" and impact more than AFLC. Hence, to smooth out the peaks and valleys in the disbursement workload would result in other workload being disrupted and other customers being impacted. The Accrued Expenditures Unpaid portion of the Finance Center operation was analyzed since that area directly impacts on disbursements. That analysis is documented in the body of this report.

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Several analyses were performed to develop a method for forecasting monthly disbursements for GLA 500. The two methods which were determined to be best are essentially comparable from an accuracy standpoint. The two methods were: time series regression, and a straight-line monthly factor (0.083) of annual projections. The distributions of residual errors resulting from the two forecasting methods, plus the current method, for the period December 1986-April 1991 are shown below:

Method	Actual Minus Forecast ($ million)								Average
	< -60	-40 -60	-20 -40	0 -20	0 20	20 40	40 60	> 60	
Current Method	9	3	7	7	7	9	2	8	40.8
0.083 Month. Factor	1	3	10	11	16	7	3	1	22.6
Regression	1	1	10	12	17	6	5	0	21.9

In all three cases, forecasts are split fairly evenly between over forecasts and under forecasts. It should also be noted that in the case of the "0.083 monthly factor" and "regression" forecasting methods, even though the average forecasting error is approximately $22 million, large errors are possible for individual months. The two methods had errors in excess of $40 million during eight and seven months respectively during the December 1986-April 1991 period examined. If this frequency and/or magnitude of error is unacceptable, FMB can add a "safety level" to the forecast value to guard against months where the actual disbursements are higher than the forecast. Of course, that "safety level" will increase the excess in the months

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where the forecast is already larger than the actual disbursements.

Observations/Recommendations

This study examined forecasting methods based on: moving averages, exponential smoothing, data lags to simulate leadtime, regression, time series analysis, and monthly factoring of annual disbursements. Two methods were judged to be best based on the average absolute value of the residual error between the actual and forecasted monthly disbursements. The method based on time series analysis of historical data resulted in a negative slope of approximately $1.5 million per month. While this method is acceptable for near term projections, care must be used as the forecast horizon is increased. The other method, based on assigning a factor to each month, should not produce similar adverse effects as the forecast horizon is increased since major changes in operational environment will have already been captured in the annual figures that the monthly factors are applied against. The normal cautions always exist regardless of what method is used; namely that as time passes the assumptions and trends that existed in the data which generated the forecasting method could change and require modification.

The recommendations from this study are:

1) Use a monthly factor of 0.083 to allocate the annual disbursement projection to monthly increments. Previous studies by XRII (formerly MMIS) have indicated that the annual projections have a mean absolute percent error of 5.3%, a rate that FMB has

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indicated they can live with.

2) Give consideration to establishing a "safety level" to increase the forecast sufficiently to preclude unacceptable cash shortfalls during those months where the forecast is less than the actual disbursement. This is an area that FMB must address. Although XPS can not directly make a recommendation in this area, if FMB is able to quantify the degree of risk they are willing to take regarding a cash shortfall, XPS can assist in determining the size of any "safety level" established. As stated previously, the establishment of a "safety level" will amplify the funding excess for those months where the forecast already exceeds the actual disbursements.

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COMPARISON
GLA 500 AND TOTAL OF 11 GLAs

DOLLARS (MILLIONS)

MONTHS

■ TOTAL   ▨ GLA 500
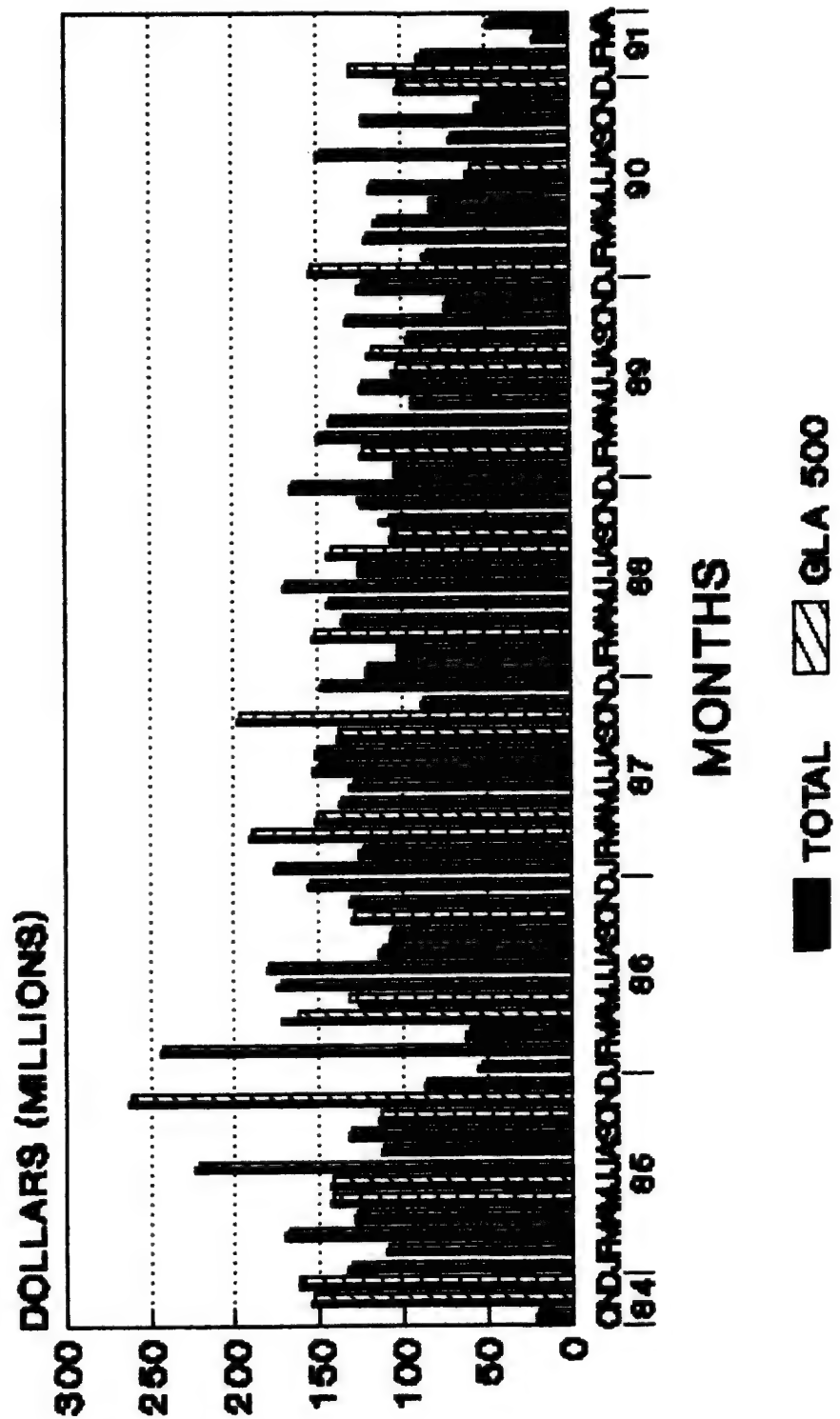
Figure 1   16

GLA 500 OUTLAYS VERSUS TIME

DOLLARS (MILLIONS)
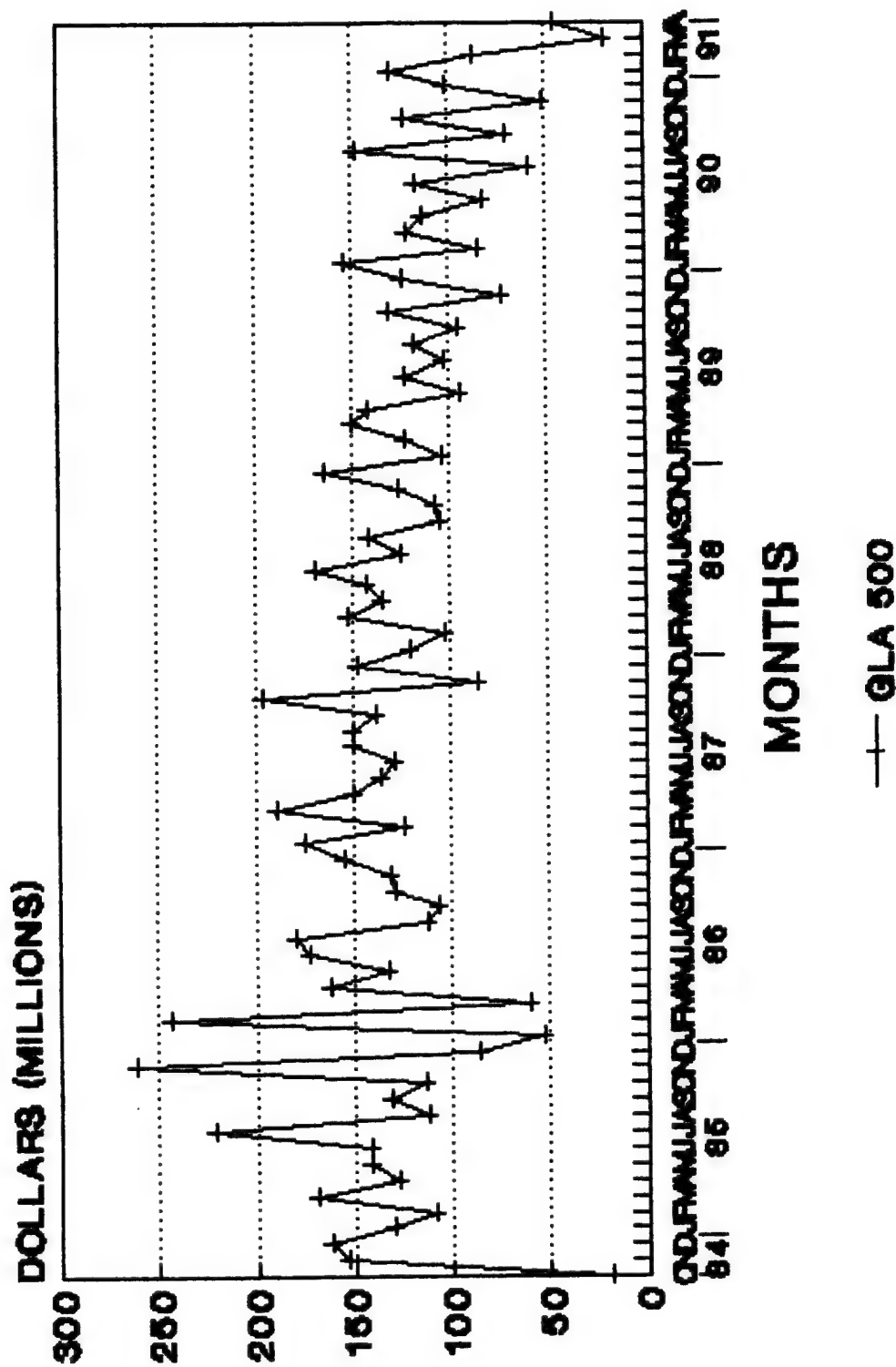
MONTHS

—+— GLA 500

Figure 2   17

GLA 500 HISTOGRAM OF MONTHLY OUTLAYS
(OCT 84–APR 91)

Figure 3

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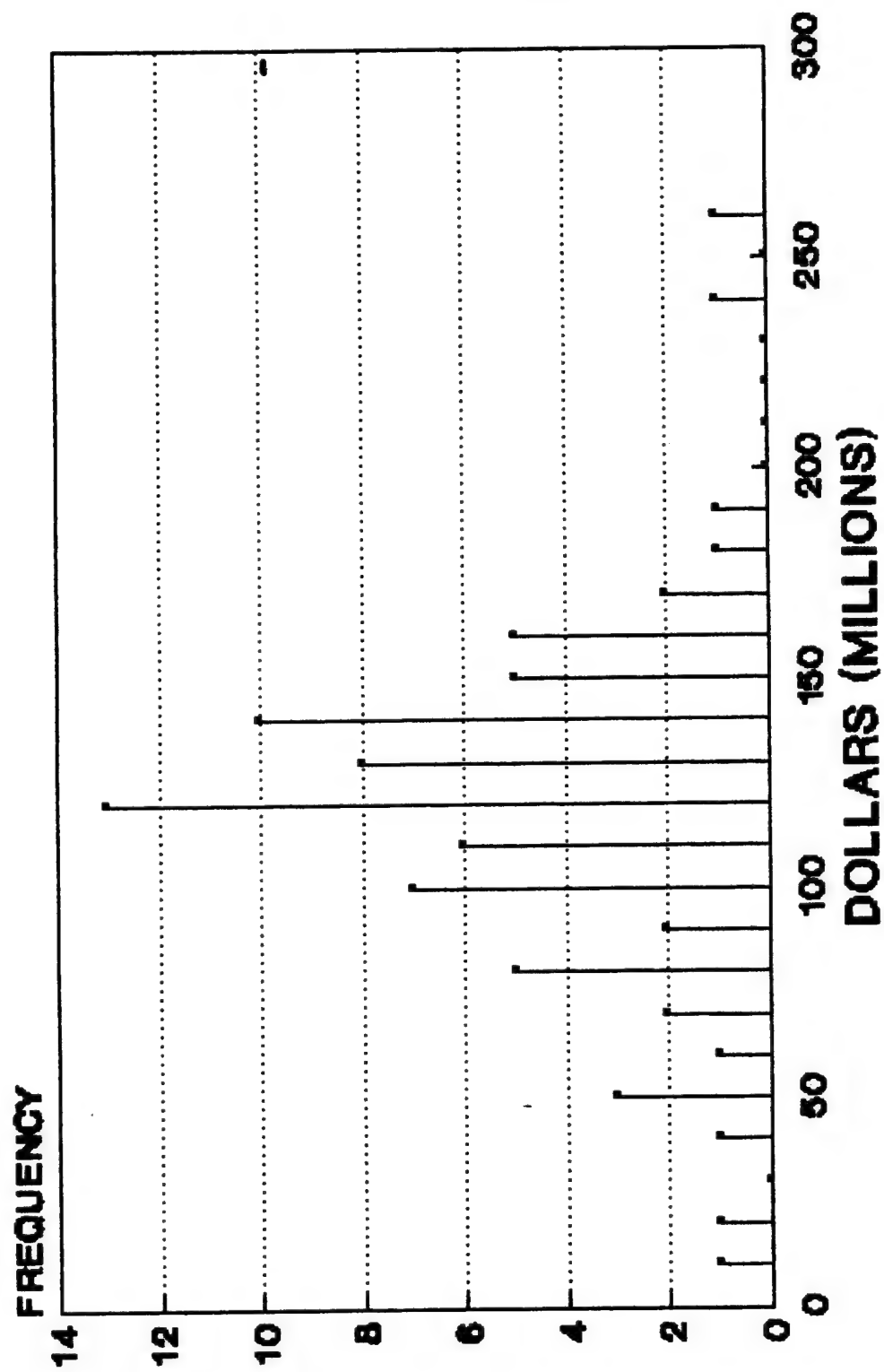
AVERAGE OF RESIDUAL ABSOLUTE VALUES
GLA 500 MINUS OFFSET OF GLA 500
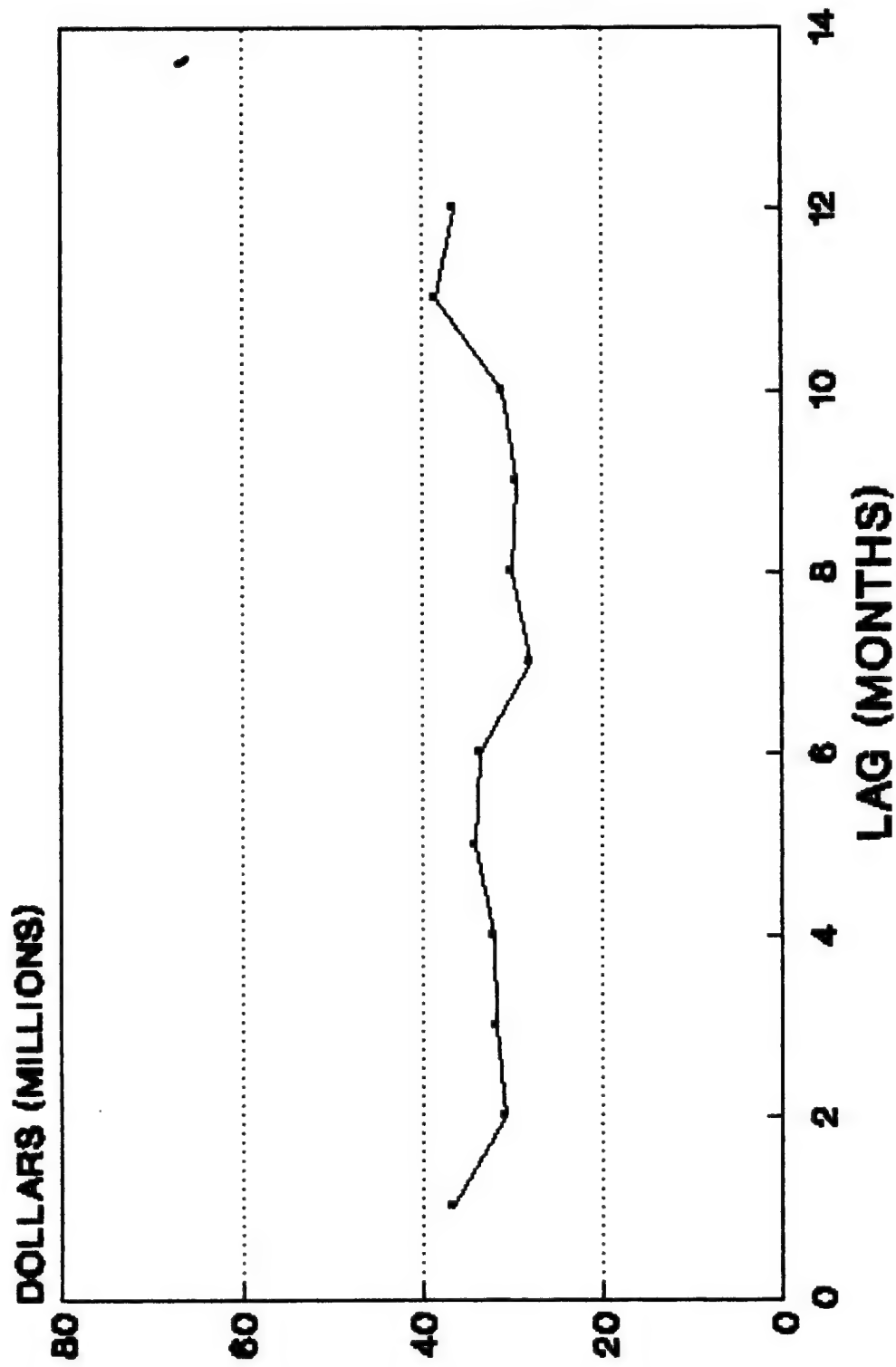
Figure 4

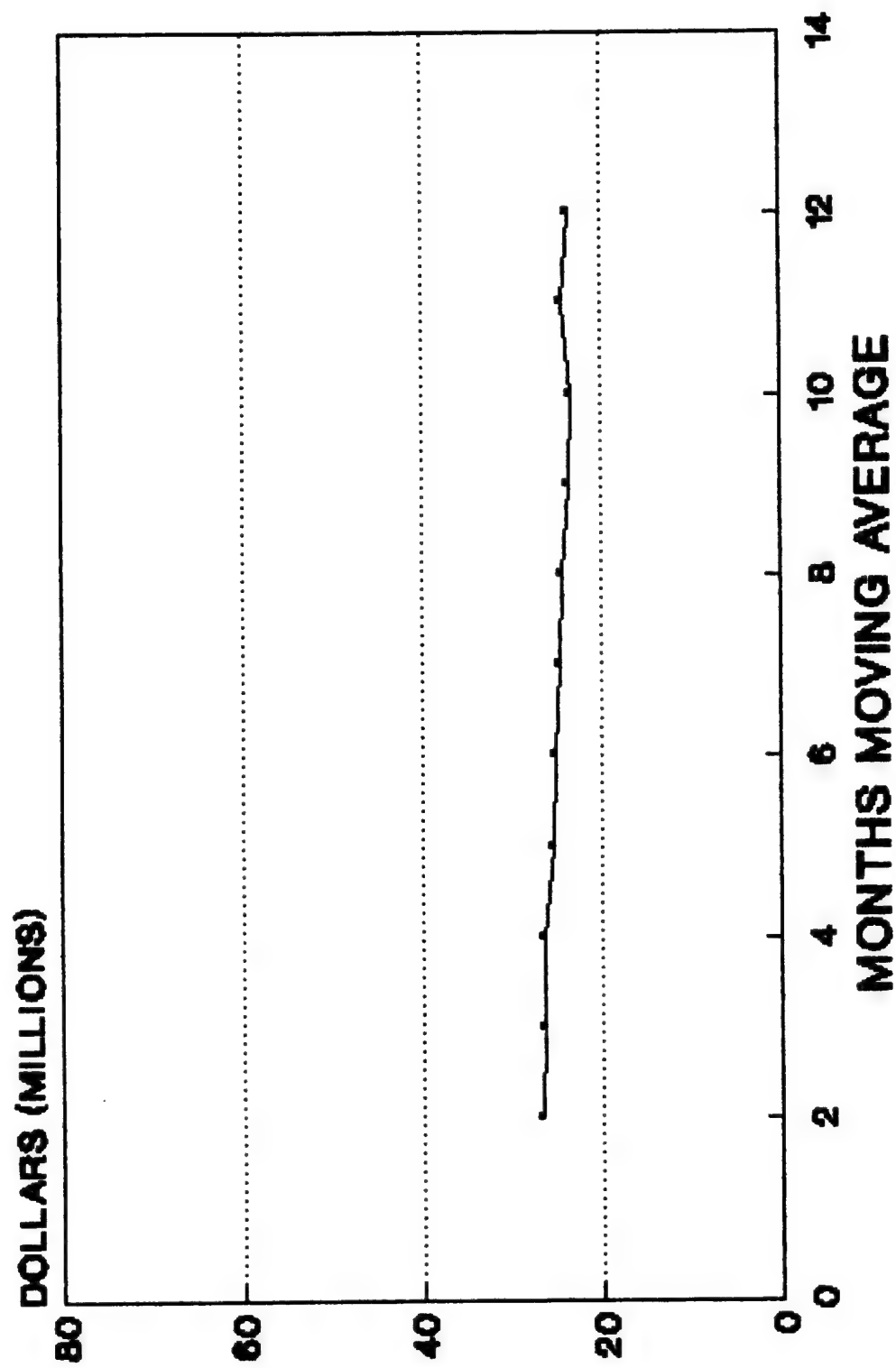# AVERAGE OF RESIDUAL ABSOLUTE VALUES
GLA 500 MINUS MOVING AVERAGE

Figure 5

AVERAGE OF RESIDUAL ABSOLUTE VALUES
GLA 500 MINUS EXPONENTIAL SMOOTHING

DOLLARS (MILLIONS)

EXPONENTIAL SMOOTHING FACTOR
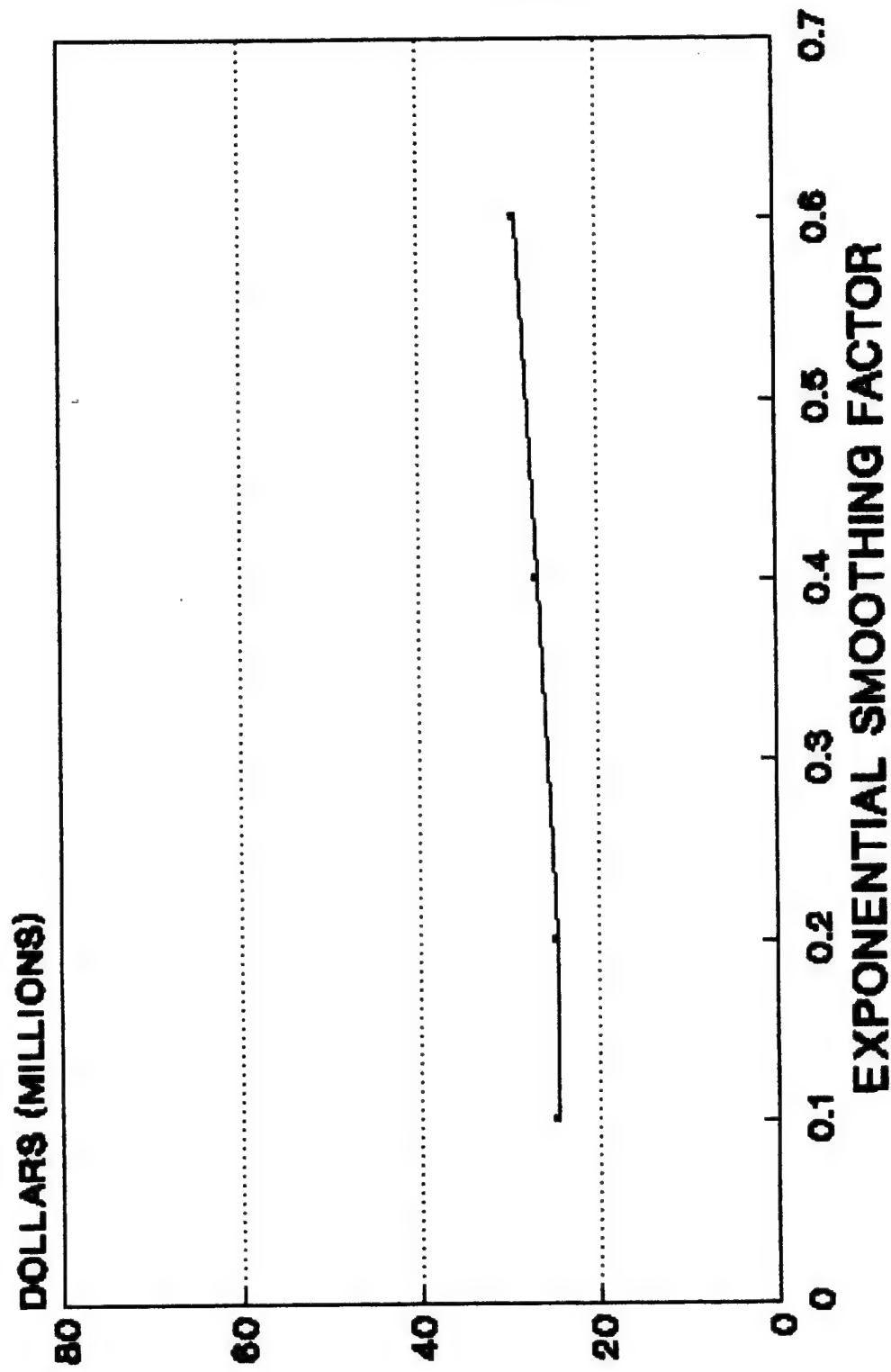
Figure 6

REGRESSION VS GLA 500
(DEC 86–APR 91)
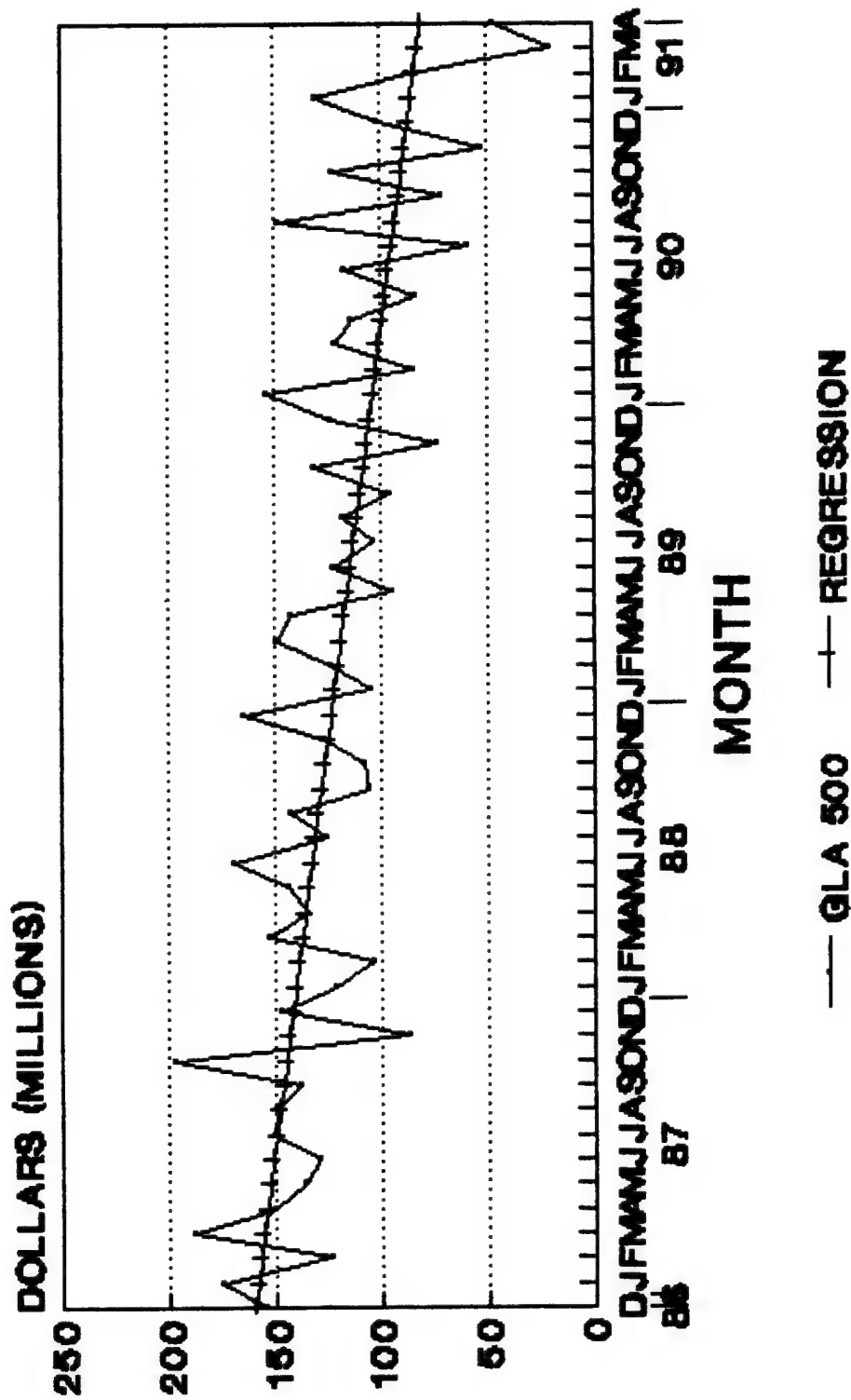
Figure 7

REGRESSION VS GLA 500
(OCT 84–APR 91)
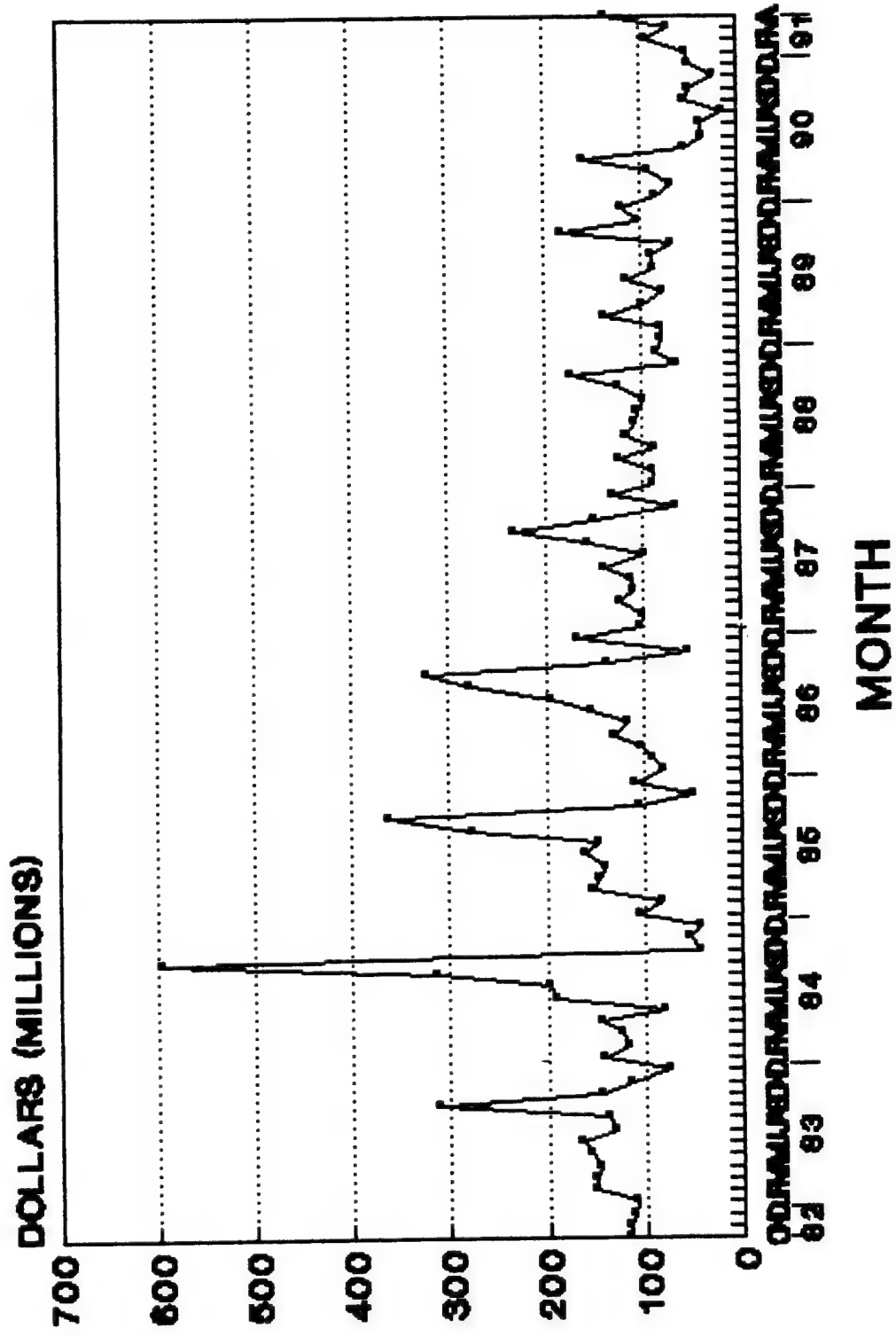
DOLLARS (MILLIONS)

MONTH

—— GLA 500   —+— REGRESSION

Figure 8

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OBLIGATIONS

DOLLARS (MILLIONS)

MONTH

Figure 9

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AVERAGE OF RESIDUAL ABSOLUTE VALUES
OBLIGATIONS

Figure 10

.2 SMOOTHING FACTOR

AVERAGE OF RESIDUAL ABSOLUTE VALUES
OBLIGATIONS

DOLLARS (MILLIONS)

MONTHS LAG

.4 SMOOTHING FACTOR

Figure 11

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AVERAGE OF RESIDUAL ABSOLUTE VALUES
OBLIGATIONS

DOLLARS (MILLIONS)

MONTHS LAG
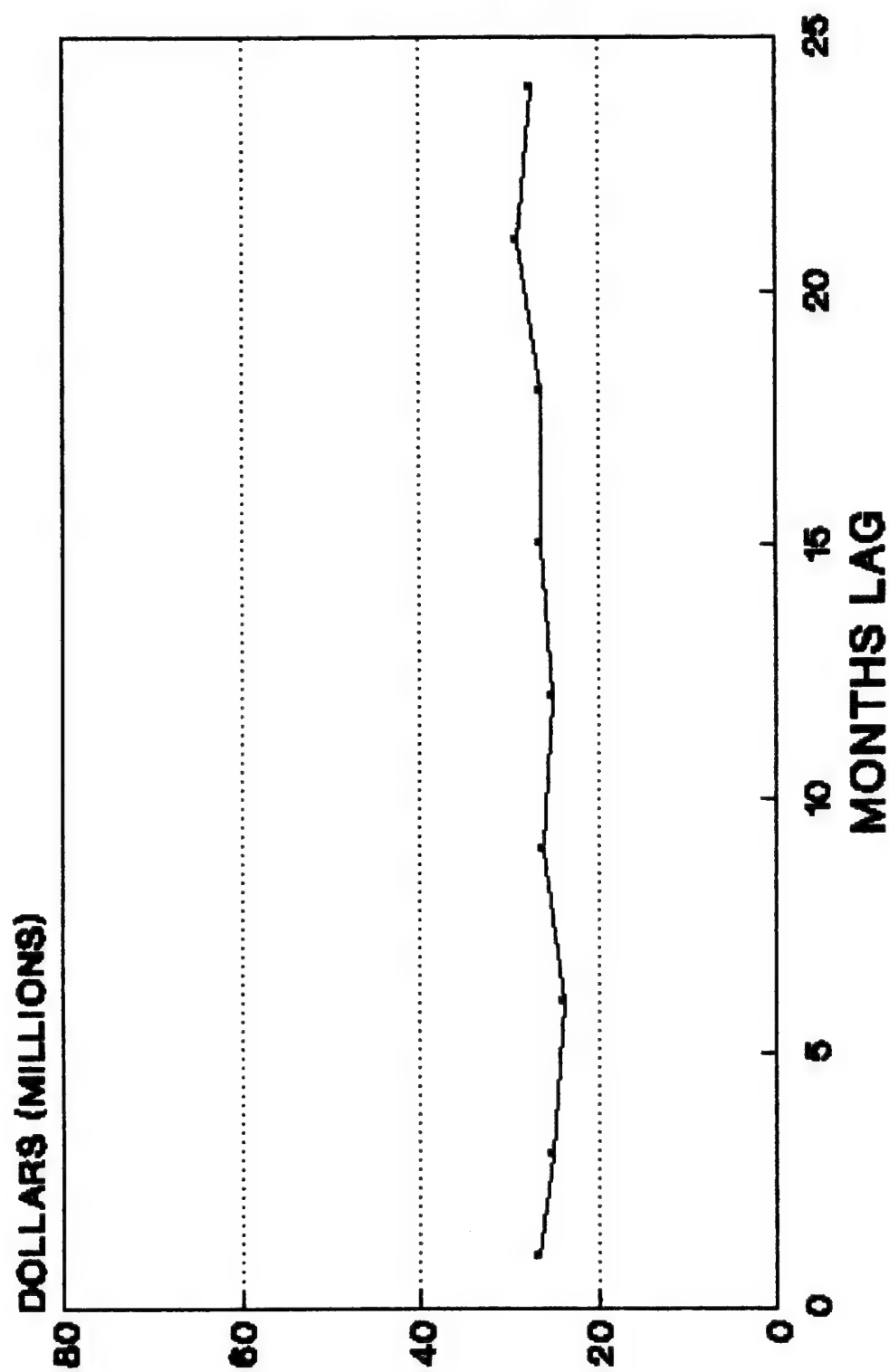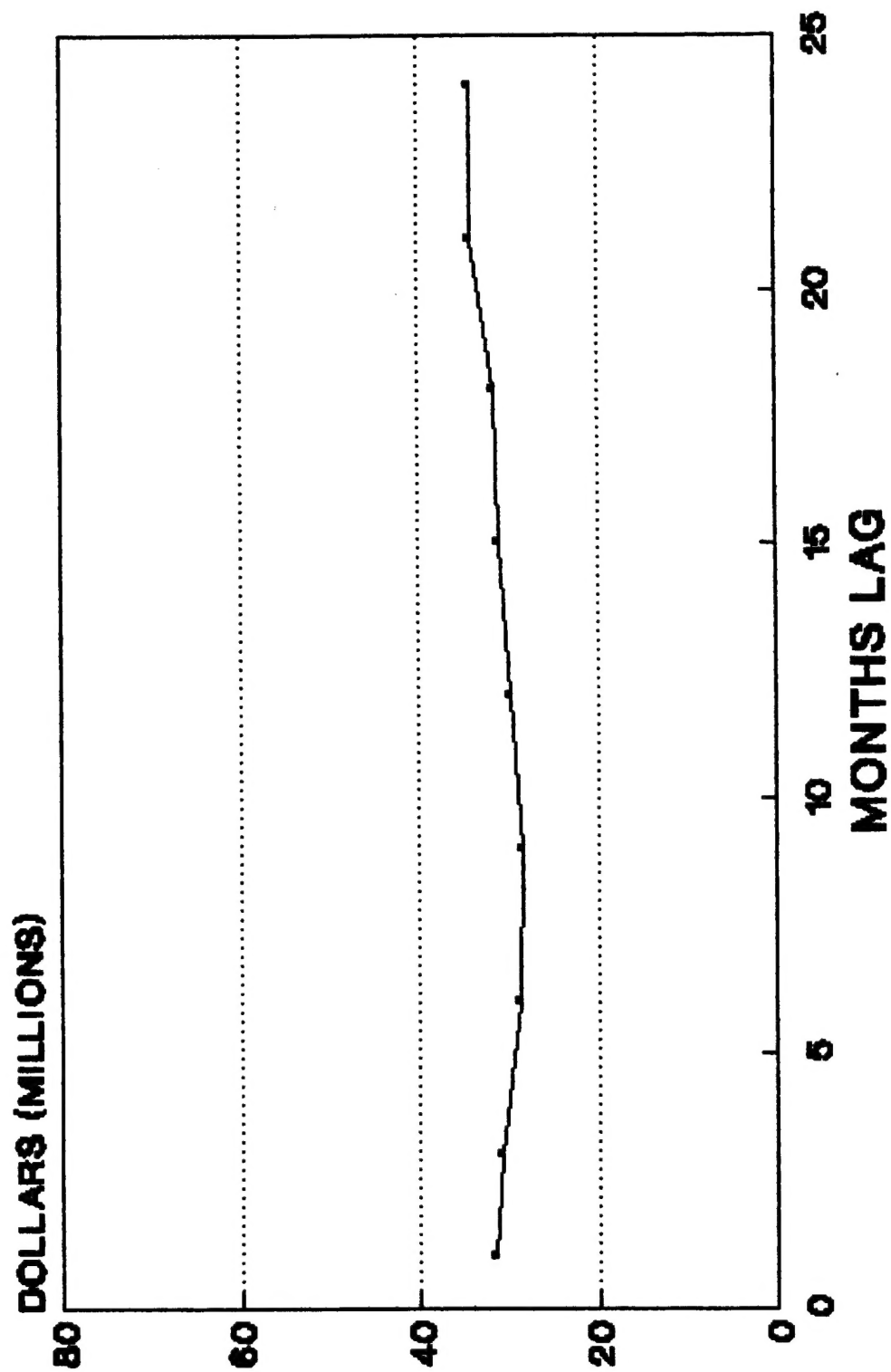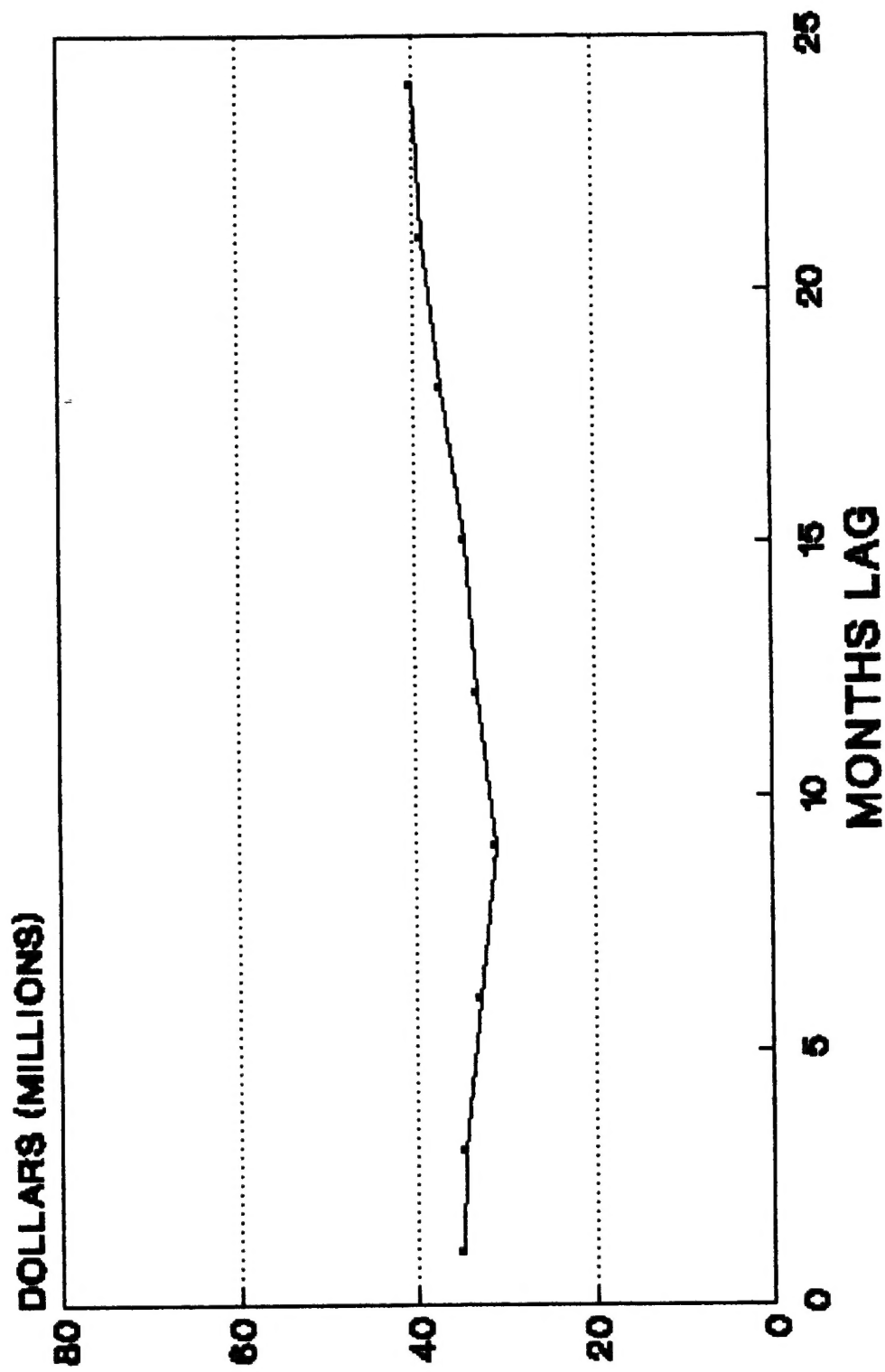
.6 SMOOTHING FACTOR

Figure 12

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COMPARISON OF GLA 500 AND OAC 45

DOLLARS (MILLIONS)

Figure 13
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MONTH
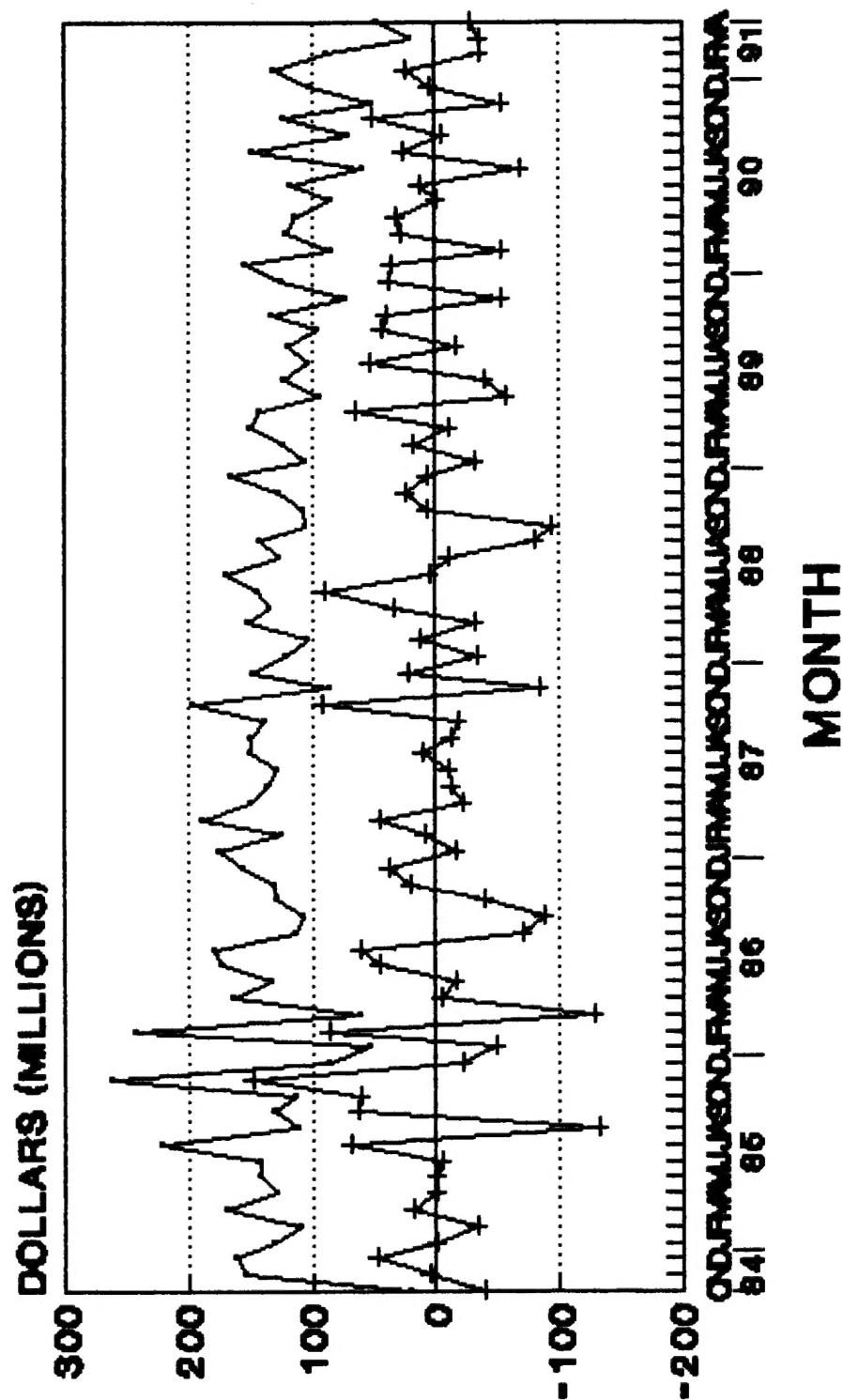
—— GLA 500   —+— OAC 45

GLA 500 MINUS OAC 45

DOLLARS (MILLIONS)

Figure 14

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